

LIGHT SCATTERING BY LUNAR-LIKE PARTICLE SIZE DISTRIBUTIONS.

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A fundamental input to models of light scattering from planetary regoliths (1) is the mean phase function of the regolith particles. Using the known size distribution for typical lunar soils (2), the mean phase function and mean linear polarization for a regolith volume element of spherical particles of any composition were calculated from Mie theory (3).

The 2 contour plots in fig. 1 summarize the changes in the mean phase function and linear polarization with changes in the real part of the complex index of refraction, $n - ik$, for $k = 0.01$, the visible wavelength 0.55 micrometers, and the particle size distribution of the typical mature lunar soil 72141. Fig. 2 is a similar "index-phase" surface, except with $k = 0.1$. Figs. 1 and 2 are only a small subset of the full range of parameters surveyed in this study, but they will serve to illustrate some of the important conclusions reached. The range of n and k spanned covers many compositions of interest and the region of most rapid change with k . The corresponding index-phase surface for dielectric ($k = 0$) particles is similar to fig. 1; the surface for perfectly conducting particles is similar to fig. 2.

Even though the increment in k is a factor of 10 between these plots and k traverses the range of most rapid change in the scattering properties of the particles, the shape of these index-phase surfaces changes slowly. Completed calculations also include the surfaces corresponding to $k = 0, 0.001, 0.003, 0.03$, and 1 to provide sufficient detail for interpolation. Note that all compositions show increasing brightness near opposition that is suggestive of the backscattering behavior observed for many regoliths. The persistent region of negative linear polarization centered near $n = 1.6$ and phase angle = 20 degrees in both figures may be responsible for the "negative branch" of polarization observed for many regoliths at small phase angles. To quantitatively relate the mean phase function and linear polarization from this survey to the observable quantities of the intensity and polarization of light scattered by an optically thick regolith, multiple scattering must be calculated.

The "index-phase" surfaces from this survey are a first order description of scattering by lunar-like regoliths of spherical particles of arbitrary composition. They form a basis of functions that span a large range of parameter-space. Only small changes in the mean phase function and polarization result if they are calculated for the size distribution of the coarse and poorly sorted, immature lunar soil 71061, at the opposite end of the range of size distributions of lunar soils. Because the Mie calculations are a function of the ratio of the particle radius to the wavelength, another consequence of the integration over a broad particle size distribution is that the index-phase surfaces are only weakly dependent on wavelength. Additional calculations show that changes in wavelength by a factor of 2 across the visible spectrum also result in only small changes to the index-phase surfaces because a factor of 2 is small compared to the decades of particle radius that contribute to the scattering. The dominant effect of wavelength on the scattering occurs through large excursions of n and k with wavelength, especially in the vicinity of absorption bands.

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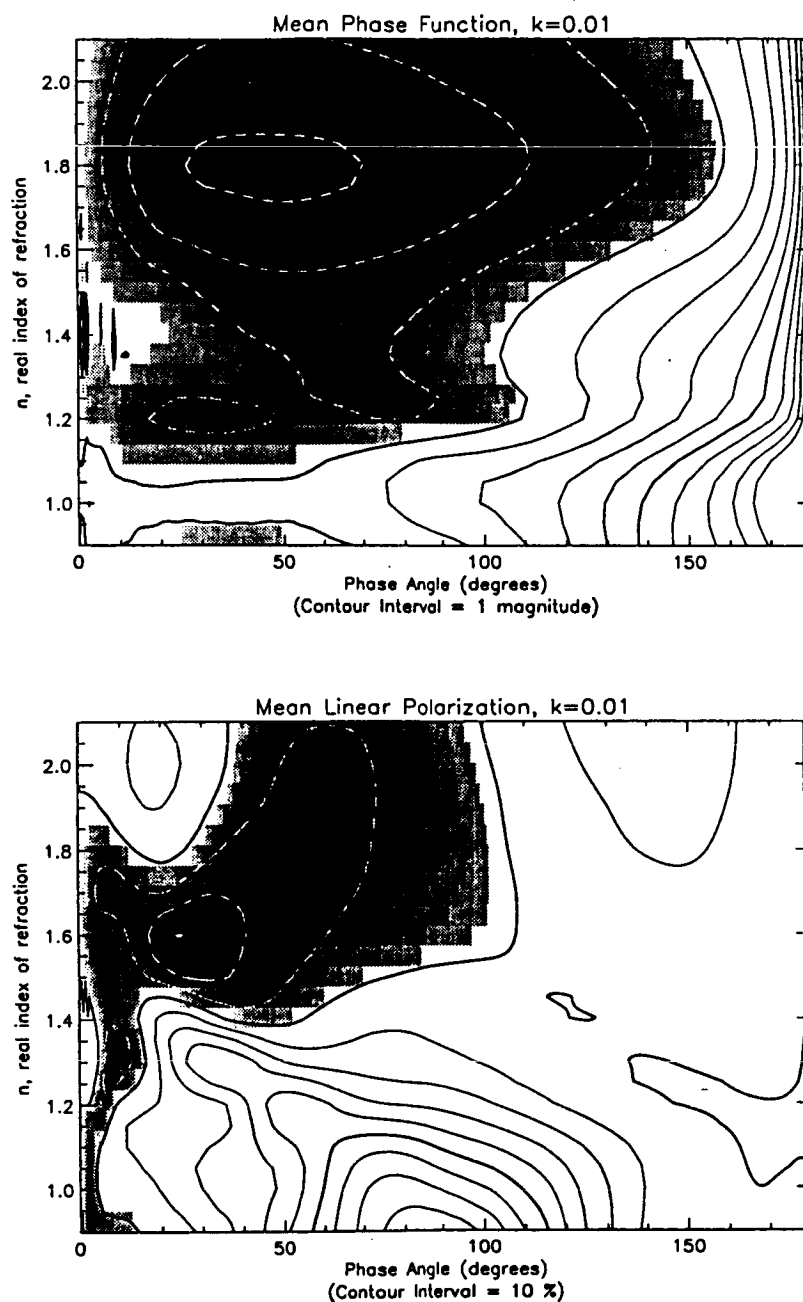


Figure 1. Contours plots of $2.5 \log \Phi$, where Φ is the mean phase function, (top) and linear polarization (bottom) for spherical particles with the size distribution of a typical mature lunar soil, 72141. The composition of the particles is indicated by the complex index of refraction, $n - 0.01 i$. In both plots, negative values are indicated by white, dashed contour lines on a shaded background. The calculations refer to a wavelength of 0.55 micrometers, but the plots are only weakly dependent on wavelength (see text).

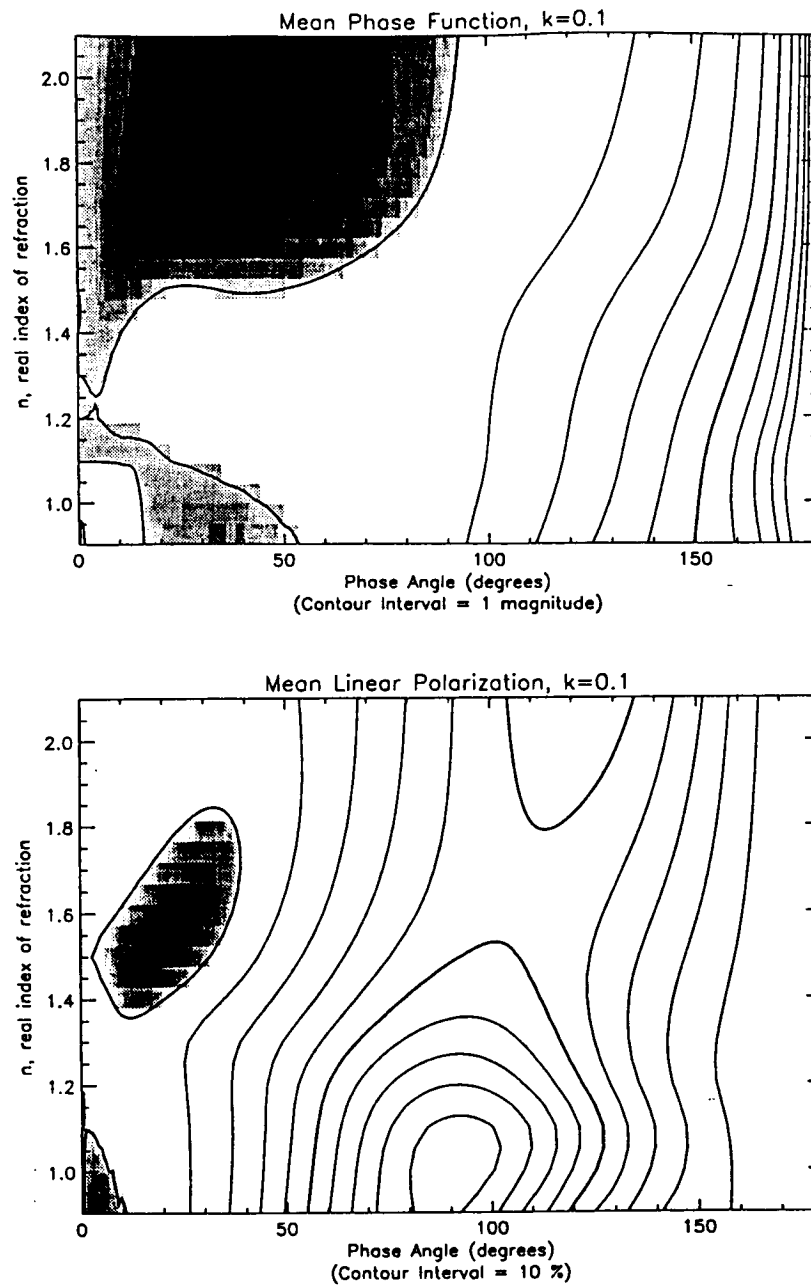


Figure 2. Same as Fig. 1, except with $k = 0.1$.